



Assessing Food Safety Knowledge, Barriers, and Resource Needs for Training Produce Farm Workers and Supervisors Following the COVID-19 Pandemic

ABSTRACT

The Food Safety Modernization Act Produce Safety Rule established standards for safe produce production, including training for personnel handling produce or food-contact surfaces and their supervisors. We investigated Maryland produce farm owners and supervisors (collectively referred to as “supervisors”) and workers regarding on-farm food safety knowledge, barriers to effective food safety worker training, and worker training resource needs following the COVID-19 pandemic. The online survey recorded farm characteristics, worker demographics, food safety knowledge, training barriers brought about by or exacerbated by impacts of the COVID-19 pandemic, and resource needs. Among 48 respondents (31 supervisors) most had less than 10 years of farm experience (70.8%). Only 27.3% correctly answered cleaning and sanitizing questions. Nearly half (45.7%) requested more hands-on training materials. The pandemic negatively affected worker food safety training by increasing stress concerning food safety and limiting time and funding for worker training (81.8%–95.5%). Another barrier to training was supervisors’

comfort with the materials used to train workers (68.2%). Five supervisors reported no training specific to workers’ duties. Time was a major barrier to effective training. Findings will inform the development of a mixed-media toolkit and supervisor manual to assist in training workers.

INTRODUCTION

A safe food supply begins with produce farm workers and their supervisors. Produce accounts for 25% of preventable foodborne outbreaks and 35% of related illnesses nationwide (9). In 2011, the Jensen Farms’ *L. monocytogenes*-cantaloupe multistate outbreak led to 33 deaths (49) and the Food and Drug Administration’s traceback investigation found that inadequate worker training—particularly in health and hygiene, and proper cleaning and sanitizing of equipment—contributed to the outbreak (49). Then, in 2014, an outbreak of *Salmonella enterica* linked to cucumbers produced in the Delaware, Maryland and Virginia Eastern Shore region and Washington, D.C. again highlighted the risks (3). These incidents underscore the need for strong food safety practices—starting with effective worker training.

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Workers are known carriers of foodborne pathogens and can contaminate produce and food contact surfaces (27, 31). Workers interact with all farm inputs—water, animals, and soil amendments—which are known reservoirs of foodborne pathogens (21, 25, 38), and contamination can occur regardless of a worker's health status (i.e., symptomatic or asymptomatic) when handling farm inputs (37), produce, or food contact surfaces (9, 26). That is why worker training is so important (47).

Under the Food Safety Modernization Act Produce Safety Rule (FSMA-PSR), worker training is focused on personnel handling produce or food-contact surfaces (e.g., conveyor belt, packing table, scale) and their supervisors (21CFR112.21-30) (50). Personnel, regardless of their worker status (part-time, temporary, seasonal, contracted), must receive adequate and appropriate training related to their duties when they are hired, periodically, and at least annually (21CFR112.21a). In addition, if a worker is not meeting standards, training must be repeated as necessary (21CFR112.21d) (50). Risk mitigation in this area is most effective when the training is delivered in an easily-understood manner for the worker(s) (21CFR112.21c) (50) and when worker trainings reinforce a strong food safety culture on the farm.

Training is critical as workers are a known potential source and vehicle for foodborne pathogen causing contamination of covered produce and/or food contact surfaces (27, 31). Workers interact with all farm inputs—water, animals, and soil amendments—which are known reservoirs of foodborne pathogens (9, 21, 25, 26, 38). For example, the Jensen Farms' 2011 *L. monocytogenes*-cantaloupe multistate outbreak led to 33 deaths (49). The Food and Drug Administration's (FDA) traceback investigation identified lapses related to worker training such as worker health and hygiene and other lapses in cleaning and sanitizing equipment were some of the contributing factors that led to the outbreak (49). The outbreak that occurred at Jensen Farms may have been avoided if the farm had a stronger food safety culture. Food safety culture is an emerging concept for farm-to-fork businesses to embrace from top management down to farm workers (4). To positively value food safety, an operation with a strong food safety culture is characterized as having shared values related to providing safe food, where employees know the risks associated with food, understand why controlling risks is important, and can demonstrate mitigation strategies (43). Maintaining this culture relies on building intrinsic motivation within workers, clear and frequent communication of the value and expectation of maintaining a strong food safety culture along with education about consequences of failing to maintain a strong food safety culture and incentives for workers to support a strong food safety culture, and, significantly, a variety of worker training tools so workers understand and appreciate their role in maintaining a strong food safety culture (43).

Specific training programs are a facet of a mature food safety culture; helping to achieve the overarching goal of preventing foodborne illness (55).

Research consistently shows that training with the intent of increasing knowledge is not effective, and current research demonstrates that addressing knowledge gaps alone may not lead directly to increased adoption of food-safe behaviors (14, 55). For example, Module 2 of the FSMA-PSR training—focused on worker health, hygiene, and training—showed the smallest improvement in pre- and post-training scores in the Southern Region from 2017–2019 (0.25) (45). At the same time, On-Farm Readiness Reviews (OFRRs), which offer confidential, discussion-based assessments of farms based on FSMA-PSR conducted by regulators and educators before inspections (33), revealed a consistent gap between growers' self-reported confidence or perceived high knowledge in food safety-worker training (46) and consistently poor results of less than adequate practices observed during OFRRs (34, 45). This suggests that knowledge-based training alone is not effective. Indeed, when looking at the Northeast region's (Maryland's regional group) response by farm size with OFRRs—a service to gauge farm alignment to the FSMA-PSR—they found that small and mid-sized farms in particular require more technical assistance in worker training to become compliant under the FSMA-PSR (4, 34). These findings highlight a disconnect between supervisors attending FSMA-PSR trainings and actual worker behavior on the farm. Inadequate worker training often stems from limited resources, lack of trainer expertise, and insufficient management support (46). Additionally, how training practices changed during the COVID-19 pandemic remains unclear, but may have long-term implications for future training delivery.

A needs assessment is a systematic process used to identify priorities, develop strategies, and allocate resources to address identified stakeholder requests (18). One common method for conducting a needs assessment is through surveys, which can guide later decisions (16). The objectives of this study were to evaluate farm supervisors' and workers' on-farm food safety training knowledge, challenges, and resource needs following the COVID-19 pandemic. The analysis will be used to inform the development of worker training materials, including a Worker toolkit and a Train-the-Trainer program, to provide the tools needed to train farm workers in targeted tasks that have been identified as deficient in recent farm food safety surveys, and assist farm supervisors in maintaining a robust food safety culture where all employees value food safety.

METHODS & MATERIALS

Recruitment

This research received Institutional Review Board approval for human subject research (#1850630). Participants were recruited from all of Maryland's 23 counties and Baltimore City. Farm workers, volunteers, and supervisors were

recruited using snowball sampling, the Maryland Food Safety Network, via recruitment ads placed in listservs, which included but were not limited to the Maryland Department of Agriculture, the DelMarVa Farmer newsletter, the University of Maryland, the University of Maryland Extension and the University of Maryland Eastern Shore Extension resources (e.g., Extension Agents, county newsletters, social media, and word of mouth). To access the survey via Qualtrics, a QR code and/or a web address was provided. Eligibility included the following: worked on a farm in Maryland in 2021; the farm grew fruits and vegetables; persons identify either as an owner, supervisor, worker (full-time, part-time, or seasonal), or as a volunteer; persons had to be 18 years or older; and persons read English. The survey was available from January to March 2022. Participants could submit their name, email address, and mailing address to enter into a raffle to receive a \$10 gift card. Gift card winners were notified between March 14th and 20th, 2022, if they won in the random drawing using free online tools like <https://miniwebtool.com/random-name-picker/> and wheelofnames.com to generate random names.

Survey design

The survey was prepared for Maryland farm workers (and/or volunteers), supervisors, owners and/or co-owners. There were 55 total questions, but skip logic was used based on how participants self-identified as a co/owner or not a co/owner. The average survey length of 10 minutes was projected from the Qualtrics “predicted duration” calculator. The length was confirmed when two team members completed the survey in approximately 10 minutes. Due to the sensitivity and pace of events during the pandemic, the survey was reviewed by the research team, which included two Extension specialists, an agriculture and family & consumer sciences agent, and a former specialist who is now a private industry consultant. The content included farm characteristics, respondent demographics, training material and delivery preferences, applied farm knowledge, current food safety behaviors, and changes during the COVID-19 pandemic. The survey included Likert scale, multiple choice, select all that apply, and fill-in-the-blank questions; all questions focused on how the COVID-19 pandemic disruptions affected the current working environment for FSMA-PSR worker training and education. Questions for co/owners included, “Since the pandemic, what have been your biggest barriers with training and adopting food safety practices by workers/volunteers on the farm.” All participants were asked “How often are you involved with training and educating farm employees in Maryland?”

Data analysis

Survey data were exported from Qualtrics (Qualtrics, Provo, UT) and prepared using R statistical software (R Core Team (2021)). Descriptive statistics were analyzed as percentages for each survey question item. Likert response

survey items were collapsed from five response options (Never, Rarely, Sometimes, Often, Always) to three response options (Never/Rarely, Sometimes, Often/Always) to aid the interpretation of survey findings. Survey responses were included if a participant answered at least one question.

RESULTS

Demographics

There were 58 survey respondents, and 37 supervisors and workers completed 98-100% of the survey. The majority of the respondents (70.8%) had been farming for 10 years or less at the time of survey administration (Fig. 1). Findings from the farm owner-specific questions (n=31, Fig. 2) showed that most sold their produce at fresh markets such as Community Supported Agriculture (CSA) or farmers markets (76%), and these respondents reported their markets provided annual gross receipts of less than \$24,999 worth of food sold in 2021 (Fig. 3, Fig. 4). Supervisors reported a gross income of over \$500,000 in 2021 (13.8%), and 45% reported between \$25,000 and \$499,000, placing these respondents potentially subject to the Produce Safety Rule requirements (barring any eligible qualified exemption or other type of exclusion) (52) (Fig. 4).

Training format

Of the 37 respondents to the farm worker-specific survey questions, 52.7% reported that the farm provides training relative to their job duties once or more than once per year, while 13.9% answered “no training at all.” The setting for this training typically occurred in the break room or farm office (44%) or in the field (41%). Most of the training was led by farm owners (42.9%) followed by supervisors (28.6%), although a small percentage reported training by the University of Maryland Extension (17.1%) (Table 1). Workers (35.7%) and owners (27.3%) stated hands-on activities were how they learned best (Table 1). When asked about time spent on training, farmer-owners thought more time could be allocated to training compared to workers (28.2 ± 27.3 min vs. 18.9 ± 20.3 min) (Table 1). No differences in reporting on learning preferences between owners and workers suggest good alignment on training material strategy between trainer and trainee.

Training content

The survey respondents used Cornell University’s Good Agricultural Practices (GAP) video “Often/Always” (29.4% reported use), and 44.1% reported using more than one resource/material for training (Table 1). The most commonly reported issue with training materials was that they were not tailored to the specific needs of individual farms (59.1%). Since the pandemic, another issue was limited time to deliver up-to-date training materials (9.1%) (Table 2). The biggest barriers with training for the supervisors since the COVID-19 pandemic, were time (95.5%), funding

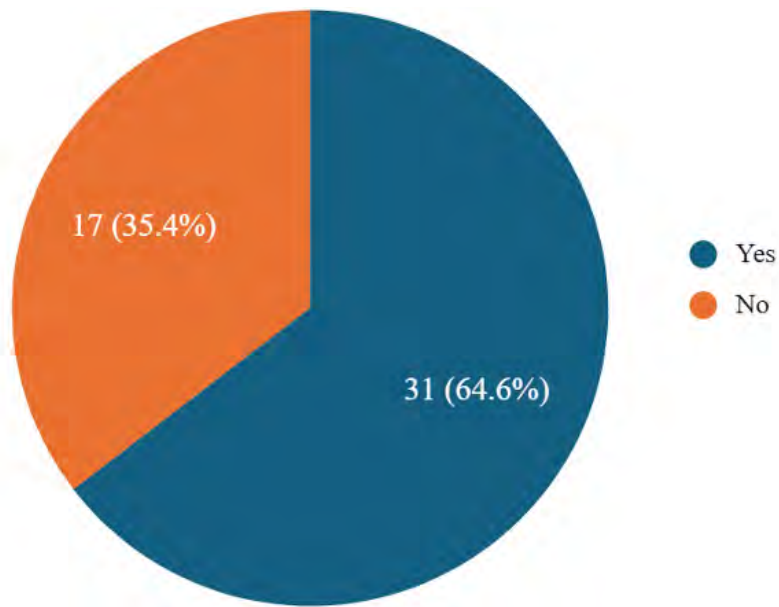


Figure 1. Demographics to survey respondents, “Do you own or co-own your farm?” n=48 responses.

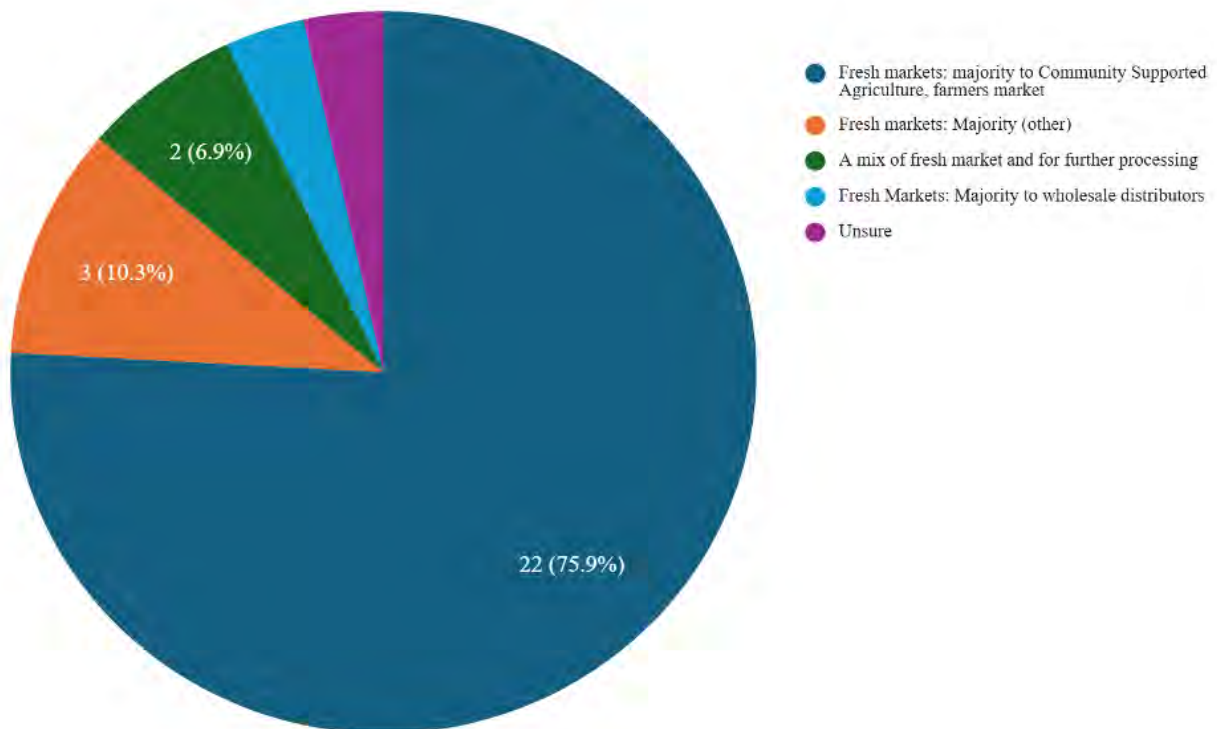


Figure 2. Demographics question to farm owners and co-owners, “How do you sell your produce?” n=31 responses.

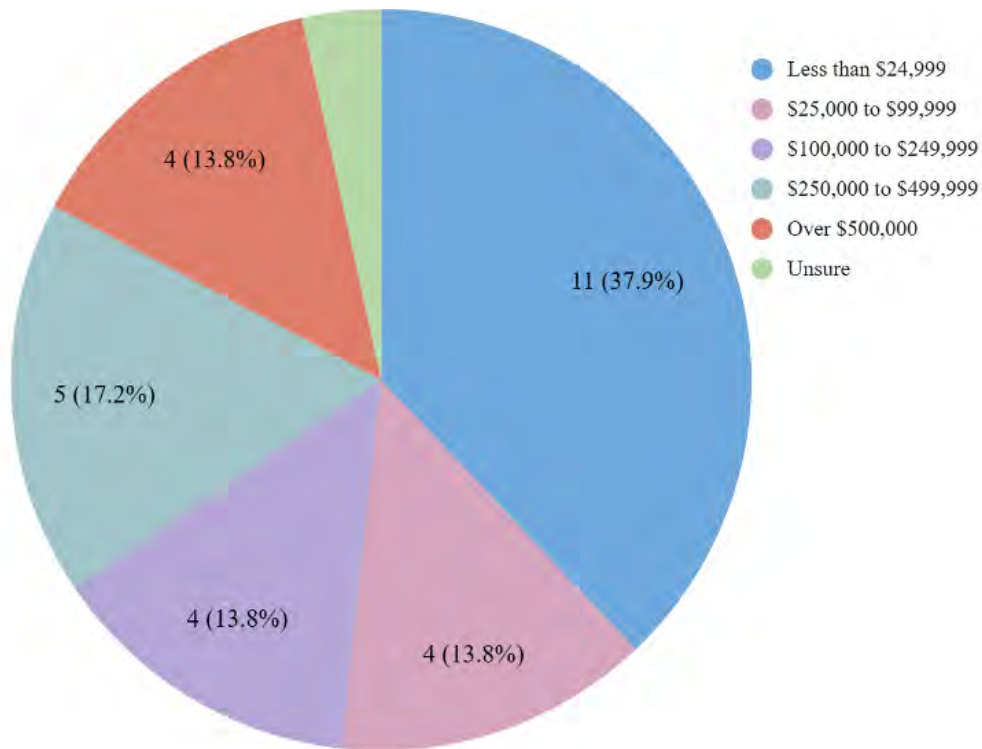


Figure 3. Annual gross amount of farm food sold in 2021, n=31 responses.

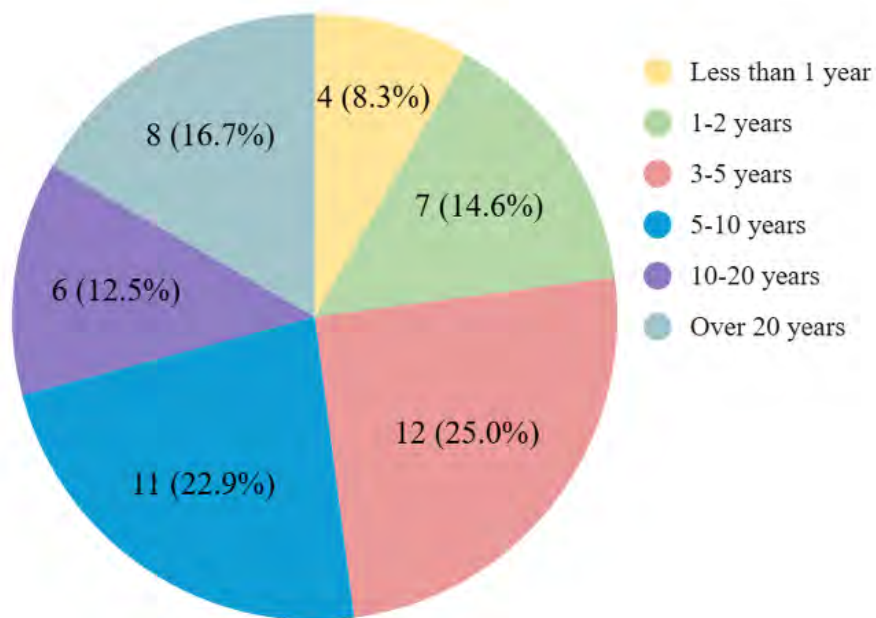


Figure 4. Demographics to survey respondents, "How many years have you been farming?" n=48 responses.

TABLE 1. Survey responses on current Maryland produce farm worker training methodologies, including how often workers are trained in food safety, who conducts training, materials used, as well as attitudes on languages needed for training, ideal training length, and adult education methods. Responses are categorized as farm owners/co-owners – collectively referred to in text as “supervisors,” workers, or other

	Owner (N=22, %)	Workers (N=14, %)	Overall (N=37, %)
How often does your farm provide training and education related to your job duties?			
No training	5 (22.7%)	0 (0%)	5 (13.9%)
Once a year	7 (31.8%)	0 (0%)	7 (19.4%)
Several times during a year	4 (18.2%)	8 (57.1%)	12 (33.3%)
Monthly	2 (9.09%)	2 (14.3%)	4 (11.1%)
Weekly	1 (4.55%)	1 (7.14%)	2 (5.56%)
Daily	0 (0%)	1 (7.14%)	2 (2.78%)
Other	3 (13.6%)	2 (14.3%)	5 (13.9%)
How often are you involved with training and educating farm employees in Maryland?			
On the farm’s office/shop/break room	11 (55.0%)	4 (28.6%)	15 (44.1%)
Out in the field	7 (35.0%)	7 (50.0%)	14 (41.2%)
Virtually	1 (5.0%)	2 (14.3%)	3 (8.82%)
Off farm	0 (0%)	0 (0%)	0 (0%)
Other	1 (5.0%)	1 (7.14%)	2 (5.88%)
Ideal length of an interactive food safety training, reported in minutes.			
Mean (SD)	28.2 (27.3)	18.9 (20.3)	24.6 (24.9)
Median [Min, Max]	12.0 [3.00, 87.00]	10.0 [3.00, 60.00]	12.0 [3.00, 87.00]
Typically, who provides the majority of the farm’s food safety training for workers?			
Owner or co-owner	12 (57.1)	3 (21.4)	15 (42.9)
Supervisor	5 (23.8)	5 (35.7)	10 (28.6)
Forman	1 (4.8)	1 (7.1)	2 (5.71)
Supplier support for training	0 (0)	1 (7.1)	1 (2.9)
University of Maryland Extension personnel	3 (14.3)	3 (21.4)	6 (17.1)
Workers come to my farm already trained	0 (0)	0 (0)	0 (0)
Other	0 (0)	1 (7.1)	1 (2.9)
Language needs for training workers. Respondents were instructed to select all that apply.			
English	20 (90.9)	14 (100)	34 (91.9)
Spanish	11 (50.0)	4 (28.6)	15 (40.5)
Korean	0 (0)	1 (7.1)	1 (2.7)
Haitian Creole	2 (9.1)	1 (7.1)	3 (8.1)
Other	0 (0)	0 (0)	0 (0)
How often is the Cornell GAP video, “Fruits, Vegetables and Food Safety: Health and Hygiene on the Farm” used for worker training?			
Never/Rarely	8 (38.1%)	9 (69.2%)	17 (50.0%)
Sometimes	6 (28.6%)	1 (7.69%)	7 (20.6%)
Often/Always	7 (33.3%)	3 (23.1%)	10 (29.4%)

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TABLE 1. Survey responses on current Maryland produce farm worker training methodologies, including how often workers are trained in food safety, who conducts training, materials used, as well as attitudes on languages needed for training, ideal training length, and adult education methods. Responses are categorized as farm owners/co-owners – collectively referred to in text as “supervisors,” workers, or other (cont.)

	Owner (N=22, %)	Workers (N=14, %)	Overall (N=37, %)
How often do you use materials other than the Cornell GAP video for food safety training?			
Never/Rarely	9 (42.9%)	4 (30.8%)	13 (38.2%)
Sometimes	4 (19.0%)	2 (15.4%)	6 (17.6%)
Often/Always	8 (38.1%)	7 (53.8%)	15 (44.1%)
How do you best learn new information?			
Sit in a lecture/presentation	1 (4.55%)	2 (14.3%)	3 (8.33%)
Read/print without images/pictures	1 (4.55%)	0 (0%)	0 (0%)
Read/print with images/pictures	5 (22.7%)	0 (0%)	1 (2.78%)
Watch a demonstration	5 (22.7%)	3 (21.4%)	8 (22.2%)
Participate in a facilitated discussion	4 (18.2%)	3 (21.4%)	7 (19.4%)
Hands-on activity (e.g., role play, case study, practice the activity)	6 (27.3%)	5 (35.7%)	11 (30.6%)
Other	0 (0%)	1 (7.14%)	1 (2.78%)

(95.5%), stress (81.8%), and having the appropriate training materials (77.3%) (*Table 2*). Although 58% of respondents mentioned having animals on the farm, working with animals was the least covered worker training topic (12 out of 37 respondents) (*Table 2*). Survey respondents reported their biggest training needs were training kits, interactive videos, and resources that facilitate hands-on activities but which do not cost significant capital or time. The requested languages for training material included Spanish (40.5%) and Haitian Creole (8.1%) (*Table 1*).

Applied food safety knowledge

Three questions evaluated participants' ability to assess risks during a day of harvesting produce. Workers outperformed supervisors in identifying correct actions for animal intrusion and safe harvesting practices (92.3% and 90.9%, respectively). Supervisors, however, were more accurate when responding to a question about handling dropped produce (95.5% vs. 61.5%). Both groups struggled with a question on cleaning and sanitizing food contact surfaces, with only 27.3% answering correctly (*Table 3*).

DISCUSSION

Our study investigated workers and supervisors on small and medium-sized farms in Maryland regarding on-farm

food safety training, knowledge, barriers, and resources needed following the COVID-19 pandemic. We expected to see changes in the working environment due to pandemic-related disruptions to FSMA-PSR worker training and education, with time emerging as a consistent concern and supervisors feeling training materials took too long to deliver, making training both problematic and a barrier. Though our work did not focus on mental health, stress was also identified as a barrier for supervisors—likely preexisting and intensified by the pandemic. For example, stress related to uncontrollable factors like weather (17) and securing a dependable labor force were noted concerns in other farm studies during this same point in time (17, 28). In a future global pandemic, effective worker training could ensure workers are trained for their duties (21CFR112.21a-c) (38), while also offering social interaction that supports the morale of farmers, who are often more isolated than those in other professions (53).

Funding was also considered a barrier to training by 95.5% of respondents. Although specific funding issues were not investigated, costs related to purchasing personal protective equipment and disinfectants, as well as the cost in extra time needed to train workers on COVID-19 health and hygiene protocols may have contributed (13, 30). Additionally, concerns about the cost of complying with FSMA-PSR (10) may have been in the back of respondents'

TABLE 2. Survey responses on current produce farm worker food safety training needs, including barriers to training, current resources used for training, as well as challenges with current training materials

Current Training Methods and Training Needs	Total n (%)
What topics are covered in current worker training programs?	37 (100%)
Healthy and hygiene	29 (78.4%)
Washing surfaces	28 (75.7%)
Translate, in-season work	26 (70.3%)
Accident, injury procedures	25 (67.6%)
Harvesting product	25 (67.6%)
Packing product	25 (67.6%)
Washing product	24 (64.9%)
Washing tools	24 (64.9%)
Working with soil amendments	19 (51.4%)
Scouting for animal intrusion	16 (43.2%)
Working with animals	12 (32.4%)
Biggest barriers with training since the pandemic	31 (100%)
Time	21 (95.5%)
Stress	18 (81.8%)
Language	14 (63.6%)
Space	15 (68.2%)
Funding	21 (95.5%)
Attitude towards food safety	14 (63.6%)
Appropriate training materials	17 (77.3%)
What is used for training?	37 (100%)
Demonstrations	22 (59.5%)
Hands-on activities	21 (56.8%)
Signs and printed flip charts	20 (54.1%)
Facilitated discussion	19 (51.4%)
Videos	15 (40.5%)
Lectures	10 (27.0%)
Other	1 (2.7%)
Owners/Supervisors: What are the problems with your current materials?	31 (100%)
Not specific to my farm activities	13 (59.1%)
Take too long to deliver	3 (13.6%)
Take too long to deliver since COVID-19 began	2 (9.09%)
Not available in the languages needed	0 (0%)
Not readily available where I train	0 (0%)
Other	4 (18.2%)
Any barriers to training?	31 (100%)
My comfort with materials that need to be taught	15 (68.2%)
Time to do the training	18 (81.8%)
Workers/volunteers struggle to understand the concepts I teach	13 (59.1%)

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TABLE 2. Survey responses on current produce farm worker food safety training needs, including barriers to training, current resources used for training, as well as challenges with current training materials (cont.)

Current Training Methods and Training Needs	Total n (%)
Workers/volunteers lose interest during the training	17 (77.3%)
Workers/volunteers understand the concepts, they just don't do it	18 (81.8%)
Workers/volunteers understand what needs to be done, they just don't know how to do it	14 (63.6%)
Expense to comply	20 (90.9%)
If we could help to provide resources for training, what resources would you like?	37 (100%)
Hands-on resources, teaching kit	16 (45.7%)
Videos (interactive)	6 (17.1%)
Facilitated discussion question sheet	4 (11.4%)
Videos (not interactive)	4 (11.4%)
Signs, printed flip charts	3 (8.6%)
Prints-digital, printed	1 (2.7%)
Something else	1 (2.7%)

TABLE 3. On-farm food safety concepts learning mastery check. Respondents were asked produce safety multiple-choice questions on topics commonly covered in robust worker training programs: scouting for animal intrusion, harvesting dropped produce, and sanitation of food contact surfaces. Correct responses refer to a selection of the best food safety management options for each question. The number of respondents answering correctly and incorrectly are reported by farm owners/co-owners – collectively referred to in text as “supervisors,” or non-owners

	Scouting for Animal Intrusion during harvest and harvesting safely		
	Owners (N=22)	Non-owners (N=14)	Overall (N=37)
Correct	20 (90.9%)	12 (92.3%)	32 (91.4%)
Incorrect	2 (9.1%)	1 (7.7%)	3 (8.6%)
	Dropped produce decisions during harvest		
	Owners (N=22)	Non-owners (N=14)	Overall (N=37)
Correct	21 (95.5%)	8 (61.5%)	29 (82.9%)
Incorrect	1 (4.6%)	5 (38.5%)	6 (17.1%)
	Cleaning and sanitizing of food contact surfaces		
	Owners (N=22)	Non-owners (N=14)	Overall (N=37)
Correct	6 (27.3%)	3 (27.3%)	9 (27.3%)
Incorrect	16 (72.7%)	8 (72.7%)	24 (72.7%)

minds, as funding needs can vary depending on farm size and the types of commodities grown (10).

Worker training overall is reported to be a shared priority across small, medium, and large farm operations although the need for training on specific food safety topics differ somewhat in terms of importance depending on the farm size (5, 6). Atis et al. (2020) surveyed apple packers of all sizes about their training needs and attitudes toward FSMA (5). They found a greater need for cleaning and sanitation training, while health and hygiene were seen as lower priorities (5). These results differed, however, from recent OFRR reports in the Northeast U.S., including Maryland (5). According to those OFRRs, the top three training needs across farms of all sizes to comply with FSMA-PSR were postharvest sanitation (39%, n=288), health and hygiene (34%, n=250), and preharvest worker training (25%, n=184) (24).

Farms earning less than \$25,000 and farms grossing between \$25,000 and \$250,000, however, required improvements in postharvest sanitation, health and hygiene, and harvest sanitation (in no particular order) (33). A white paper on on-farm produce safety knowledge and practices for small and medium farms (SMFs) identified worker training as both a need and a barrier to improvement for SMFs (19). A survey assessing worker knowledge on SMFs (n=254) showed that respondents failed to meet an 80% proficiency benchmark 42% of the time. More specifically, respondents were below proficiency in the following topics: general food safety (67%), plant/grow/harvest practices (57%), water safety (50%), postharvest handling (40%), animal-related practices (25%) and health and hygiene (25%) (41).

Training and knowledge gaps, especially around cleaning and sanitizing, are consistent concerns across the region (34), and worker training remains a critical operational need (41) as there is a significant concern about inadequate worker training in general (12, 15, 48). While increased knowledge does not guarantee behavior change (40, 44), poor understanding of food safety practices, particularly related to specific worker duties, can reduce the effectiveness of worker training as a method to prevent foodborne illnesses (32).

A farm's food safety culture—"the way we do things around here"—shapes values and behaviors related to food safety (54). The majority of our respondents (70.8%) were relatively new to farming (zero to 10 years of experience, *Fig. 1*), suggesting their attitudes and behaviors may be more adaptable (23). Indeed, 63.6% of respondents indicated that attitudes toward food safety were less of a barrier to training when compared to time and stress (95.5%) (*Table 2*). Although many of the respondents would be considered exempt from FSMA-PSR, their aspiration to grow their business positions them to be nimble and evolve with buyer and federal requirements.

Effective food safety education should address both the "why" and the "how" behind farmworker behaviors (22). Workers need to understand why certain practices matter—for example, why monitoring temperature and pH is critical when using chlorine in a dump tank to prevent cross-contamination—and how to carry out those tasks correctly. Survey results revealed gaps in specific food safety concepts when workers were challenged with making risk-based decisions during practical farm scenarios (*Table 3*). The findings underscore the need for training materials that are practical, farm-specific, and focused on developing a risk assessment mindset, rather than focusing solely on food safety theory (19).

This survey was limited in the number of participants who responded, which may not be unusual for produce grower surveys (5, 7), as produce growers are considered a hard-to-reach audience (32). Survey fatigue may have impacted our sample size because our survey was not the only survey produce growers were asked to complete by other stakeholders (e.g., Department of Agriculture). Another limitation outside our control was that our application for Institutional Review Board approval was delayed in the fall of 2021, which left us with a shorter window to solicit participants from late January to early March of 2022. In Maryland, winter (January to March) is a time for farmers to receive professional development, whereas the more active farming season begins in March. Though we provided an incentive to complete the survey, compared to other farm surveys being done at the time, the fact that participants had to complete the survey online, they only received \$10 in compensation, and they had to provide identifying information (i.e., name, address, phone number) required by university protocol for giving gift cards may have also contributed to the low number of respondents. The limited sample size may have been in response to what farm workers and supervisors might have interpreted as a "sensitive" survey during a sensitive time. We recognize the unique situation of the pandemic and the pace to quickly capture the most information to develop training materials during this time.

This study also aimed to evaluate on-farm training knowledge and resources to improve farm food safety behavior. While 33.3% of workers and supervisors reported receiving training and education related to their job duties several times a year, five owners indicated that "no training" was provided. While the workers reported receiving training at least once a year or more to comply with FSMA-PSR (21CFR112.21a) (50), there seems to be a gap for supervisors—raising the question of how supervisors improve their knowledge and prepare to effectively train their workers.

When asked about current food safety training, supervisors frequently reported "often [or] always" using the Cornell Good Agricultural Practices video, which is aligned with a different and voluntary food safety program, not the mandatory requirements of the FSMA-PSR (21CFR112.22c)

(28, 51). Although FSMA-PSR requires training to cover hygiene and food safety principles (21CFR112.21a) (50), both workers and supervisors most commonly cited health and hygiene as a focus (78.4%) only depending on buyers' requirements. Again, worker health, hygiene, and training, which is emphasized in Module 2 of the FSMA-PSR training, remains a top priority for buyers, inspectors, and growers, (6, 45), yet may not be fully implemented on all farms, as our survey captured.

When building a training program, it is important to recognize there are various styles to educate people to increase their learning (36). The VARK model—visual, aural, read/write, and kinesthetic—learning styles (36) are easily understood by workers (21CFR112.21c) (50). Our study found that both workers and supervisors preferred kinetic, visual, facilitated discussions (aural), and print materials (read/write) to learn new information, and were currently using these methods, similar to other agricultural audiences (1, 33), while images and printed materials were preferred to help reinforce prior knowledge. These findings indicate that 1) hands-on activities are preferred for adult learners to understand new concepts and 2) multiple methods of content delivery may be necessary to drive concepts and influence behavior change (2).

Many farmers, however, felt that training materials were too generic and needed to be tailored to their specific operations. For example, while over half of respondents had animals on their farm, very few incorporated animal handling and food safety into their training, despite the availability of relevant resources (2). This suggests a need to work more closely with farm communities to develop specific, adaptable materials. This is logical, as FSMA-PSR implementation on farms does not follow a “one size fits all” approach, and neither should training materials.

Another consideration is increasing collaboration with county or state Extension professionals to help farmers identify additional resources that they themselves do not have time to search for, such as the Food Safety Clearing House or other land grant university outreach and educational resources (2, 35). Extension personnel can also assist farmers with adapting materials for their particular farm. This would enhance Extension's role in providing technical assistance to farmers in connection with worker training (Table 1).

Best practices for developing on-farm training materials exist (8), but they may not always be easy for workers to understand (Table 2), despite FSMA-PSR's requirement that worker training materials be easily understood (21CFR112.21c) (50). The success of these interventions and training for growers is still an emerging area (32). In addition to increasing knowledge, food safety training aims to create lasting behavior changes (19). Research from Egan et al. (2007) shows that management's commitment—demonstrated by a positive attitude and willingness to

train others—plays a key role in reducing food safety risks, supporting the point that training and culture (i.e., sustained adoption of practices) are connected (20). In addition to personnel support, the availability of training resources and equipment enhances the training experience and results in higher adoption of food safety behaviors (20). Five of the supervisors (22.7%) in our study mentioned that the farm provided no training and education related to their duties, so there may be a unique opportunity to create a supervisor manual to help improve the training capabilities of supervisors. To our knowledge, a train-the-trainer does not exist as it relates to training farm workers to comply with FSMA-PSR, but has been encouraged (37). A literature review of produce training research highlights a void in how trainers are trained and their impact on worker behavior (32).

As we move to a New Era of Smarter Food Safety, creating a worker toolkit and a supervisor train-the-trainer for a younger and potentially “captive” audience gives the research team a chance to explore how to improve food safety culture, which is typically more established among retail and processing/manufacturing sectors in the farm-to-fork continuum and is a bit novel in the farming sector (4). Respondents identified time as a major barrier to training (Table 2), with supervisors preferring sessions under 30 minutes and workers under 20 minutes. Given the dynamic nature of daily farm tasks and the pressure of short growing seasons, it is understandable that finding the time to train is a significant barrier. To address this, educational materials should be designed to meet workers where they are—delivering focused, single-objective lessons that can be completed efficiently during breaks. Providing tools to improve a very small, small, and medium-size farm's food safety culture can hopefully strengthen the applied food safety knowledge into realized practices, and prevent future foodborne illnesses and outbreaks related to produce.

CONCLUSION

Robust worker training programs are an important tool farm owners can use to ensure FSMA-PSR standards are met, and to protect produce from contamination during growing, harvesting, and packing. Our targeted post-pandemic survey of small and mid-sized diversified farms in Maryland found a need for more worker training, professional development, and technical assistance to help farm owners and supervisors meet FSMA-PSR minimum standards and develop a strong food safety culture on their farms. Survey respondents indicated that short, interactive and hands-on training materials were the preferred tools and methods to use for training workers. That information will guide the research team's focus when working with New Mexico State University (NMSU) to develop a worker toolkit and train-the-trainer manual for farm owners and supervisors. The development of the toolkit and train-the-trainer manual will be worker-

informed with direct input from farm workers and farm supervisors, and incorporating Adult Learning Theory (29). It will utilize mixed media developed by NMSU to convey concepts and content with methods that meet the needs of the targeted farm workers and their handling of specialty crops with an emphasis on high-risk commodities, including but not limited to tomatoes, leafy greens, cantaloupes, spring onions, berries, fresh herbs, cucumbers, and peppers. Visual and tactile learning aids will be distributed in the toolkit to reinforce training concepts and appropriate actions for targeted tasks.

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